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Abstract

For the sustainability of development, effective usage of sources and the determination of their optimal usage levels are very important. Healthiness, as one of the main components of sustainable development, is under influences of many factors one of which is nutrition, and the number of people who benefit from public nutrition services are increasing every day.

The growth in the number of people necessitates that an effective menu planning must be done in order to keep the continuity of sustainable public nutrition systems.

In this study, detailed plans of 20 days' lunch menu lists are prepared for workers who are at the age of between 19 to 30 years old. Fuzzy 0-1 integer linear programming technique was used during the planning process with the consideration of data's fuzziness. Carlsson-Korhenon approach, which is offered for the situations when all parameters are fuzzy in the model configuration, is applied.

Keywords: Menu Planning, Nutrition, Fuzzy, 0-1 Linear Programming.

Jel Codes: C44, C61, Q01

1.INTRODUCTION

Brundtland Report defines sustainable development as a development understanding which meets the needs of today's generations without endangering the meeting ability of future generations (Çetin, 2006). Sustainable development involves environment, economy, socio-demographic and health elements (Çelik, 2006). Health, as one of the main components of sustainable development is under the influence of some factors such as nutrition, heredity, climate and environmental conditions. Among them, nutrition is the primal one (Baysal, 2009).

Public food service system (PFSS) has become an important part of our lives as a result of recent changes such as technological developments, transition from agricultural society to industrial society and socio-economic and cultural changes of urban life. PFSS is defined as the system via which people, who are either at home or working outside of their home, can meet the food needs just as they wish to have it without going outside from their place. PFSS institutions are those kinds of establishments that can programme and manage nutritional needs and problems of specific groups from a single center. Places and institutions in which people usually exist publicly and eat together are hospitals, schools, universities, nursing homes, prisons, armies, hotels, offices, restaurants, institutions and factories (Atılan, 2008).

In the past, it was thought that only 10 or 15 percent of the general population benefit from PFS. According to 2010 census data the rate of working people in Turkey reached up to % 50.5 (TÜİK, 2011). Therefore it can be inferred that the rate of people who benefit from PFS also increased (Atılan, 2008).

The rapid growth in the world population increases the need for food and inadequacy of agricultural production rises food prices (Kaypak, 2011). If the rapid growth tendency in population, food production and consume of resources continue without any change, human being will reach development limits of the planet in the next century (Kaypak, 2011).

In sustainable development the biggest target is to maximize the benefits and values of sources for society. It is necessary in terms of exhaustible sources to determine optimal usage levels of them (Çetin, 2006). With the increasing number of PFS people, an effective menu

planning should be made in PFSS in the context of providing the continuity of human health and efficient use of resources.

Menu planning is a complicated process that many factors should be taken into consideration in planning such as cost, taste, variety, energy, need of nutrient etc. and mathematical models are used in the planning of the process (Şenol, 2011). It is possible to see many studies on menu planning in science literature some of which as follows: Anderson and Earle (1983), Colavita and D'orsi (1990), Soden and Fletcer (1992) Sklan and Dariel (1993) Kılınç (2007), Ediz and Yağdıran (2009), Şenol (2009), Mamat et al. (2011) and many other scholars.

The data is quite important to perform an accurate mathematical modeling. However, it is not always possible to reach required exact/precise data for menu planning. Fuzzy modeling is performed on the bases of fuzzy set theory which is developed by Zadeh (1965) when a given date is inaccurate or fuzzy.

In this study, sample lunch menu is planned to be served in three or four vessels as nonoptional menus for moderate activity job workers who are at the age of 19 to 30 years old. This plan is prepared for the companies that work 5 days a week and the schedule is thought monthly that means menus are for 20 days. Fuzzy 0-1 integer linear programming method is used during the planning process of the study and fuzziness were taken into account. In this model, 1280 decision variables and 752 constraints were used. Carlsson-Korhenon (1986) approach, which is offered for the situations when all parameters are fuzzy in the model configuration, is applied. GAMS 22.5 package program was used for all solutions.

2.Fuzzy Linear Programming

Fuzzy linear programming models are constructed by adding the concept of fuzziness to linear programming models. These models are suggested for the solutions of problematic models that have fuzziness in their parameters and can be modeled by using linear functions. Especially it provides an opportunity to express the demands of decision maker flexibly (Bozdağ and Türe, 2007).

There are many offered fuzzy linear programming models by scholars such as Zimmermann (1983), Werners (1987), Carlsson-Korhonen (1986). These models change according to their fuzziness in coefficients of the objective function, all parameters, objective function etc. or membership function of the fuzzy number.

0-1 integer linear programming model, which its' all parameters are fuzzy and with a objective function that is based on minimization, can be expressed as follows:

Objective Function:

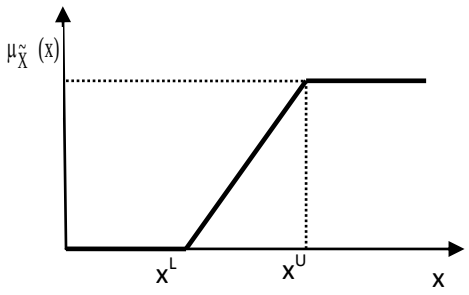
$$Z_{min} = \sum_{j=1}^{n} \tilde{c}_j x_j$$

Constraints:

$$\sum_{j=1}^{n} \tilde{a}_{ij} x_j \geq \tilde{b}_i \qquad i = 1, 2, \ldots, m$$

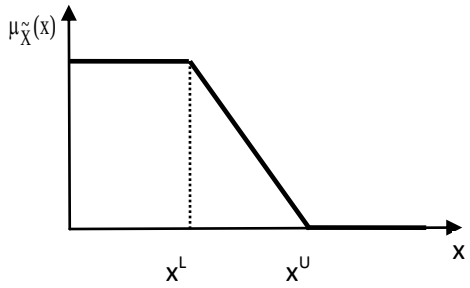
$$x_j = 0 \text{ or } 1 \qquad j = 1, 2, \ldots, n$$

According to fuzzy set theory each fuzzy number is a cluster. In the fuzzy sets each cluster members are included to set by taking a degree (μ) ranging from 0 to 1. If the cluster element takes a degree of 1, it is a full member of cluster, but if it takes a degree of 0, it cannot be a member of cluster (Abdel Kader and Dugdale, 2001:457). The function of membership can be defined in many ways depending on the situation of problem. The fuzzy number $\tilde{x}=(x^L, x^U)$ which has monotone increasing or decreasing membership function and upper and lower limit values are known can be defined as (Baykal, 2004):



$$x = x^L + \left(x^U - x^L\right)\mu_{\tilde{x}}$$

Graphic 1.Monotone Increasing Membership Function



$$x = x^U - \left(x^U - x^L\right)\mu_{\tilde{x}}$$

Graphic 2.Monotone Decreasing Membership Function

(x) values that are calculated according to (μ) refers to the degree of belonging to fuzzy set ($\tilde{x}$) of (x).

Carlsson-Korhonen (1986) suggest a linear model, which can be used in the cases when upper and lower limits of fuzzy numbers are known (namely $\tilde{c}=(c^L,c^U)$, $\tilde{a}=(a^L,a^U)$, $\tilde{b}=(b^L,b^U)$). The model can be applied to solve for different membership functions of the fuzzy number by valuing it from the applicable value (namely μ=1) into nonapplicable one (namely μ=0).

For the application of the model, it is needed that membership functions of fuzzy numbers either should be increasing or decreasing. In the model, membership function of each fuzzy

number is composed thus it is clarified from fuzziness. According to preferred (μ) value/values of decision maker, the model is solved.

3.Menu Planning in PFSS

Nutrition is the use of nutrients to protect health and provide maintenance of life. The science of nutrition deals not only with composition of nutrients (energy and nutrient quantities) but also age, gender, working conditions etc. (Baysal, 2009). In this study the nutrient amounts and quantities of required energy list in a lunch is given in table 1 as menu planning which is prepared for those who are at the age of between 19 to 30 years old and work in medium activity jobs.

Table 1. Average Amounts of Energy and Some Nutrition List Except Bread in a Lunch

Energy - Nutrition Elements	Symbols That Are Used For Parameter In The Study	Values
Energy (kkal)	E	750
Protein (g)	P	22,7
Vitamin A (μg)	A	750
Thiamin (mg)	T	0,38
Vitamin C (mg)	CV	34

Source: Ediz and Yağdıran, 2009, 73.

Non optional menu systems, which do not give permission to choose food, are generally used in the PFSS that serve working staff. The number of the food menus in the container is limited from 3 to 4 (Ediz and Yağdıran, 2009, Beyhan and Ciğerim, 1995). A skeleton of menu is created while creating non optional menus. During this process, food groups are taken as ground and later on sample food are taken from each group. Here are the main food groups as follows (Ediz and Yağdıran, 2009, Beyhan and Ciğerim, 1995):

The First Group Meals: Meat food as large and small pieces, meatballs, fish, meat and vegetable ones, dolma and sarma (Special Turkish meals), food legumes with meat.

The Second Group Meals: Soups, rice dishes, pasta, pastries, olive oil dishes.

The Third Group Meals: Fruits, salads, desserts and others.

In this study, menu plannings are prepared for in total 64 dishes groups, 22 of which are set as the first group and 18 for second group and 24 for third group. Food names and codes given for food in the study, values of energy and nutrition of a portion of food, and costs is given in the table 2. The model is established on basis of the standards below. (Note 1)

- *Food Costs (C_i):* The cost of each meal is determined as portion. However, the term "a portion" is relative itself when the weight of it and the amount of the content in a portion

are considered. The amount of water, meat, onion, potato etc. in a given portion to a worker is not going to be equal with another. In addition to this, prices of materials which are used in the preparation of a meal can also be relative; moreover it is possible to meet rotten materials in the meal too. But, it is not precisely possible to take all these variables into account in the calculation of costs. Thanks to this fact, the costs of portions are fuzzied from right and left with the percentage of 5. The feasibility of lowering the cost of a meal gets lower as the cost of meal goes down. In other words, the more the price of food increases, the more the degree of membership increase. For this reason, it is assumed as that the fuzzied number has membership function that monotonically increases.

- *The Number of Meals:* In each menu, 3 or 4 kinds of food are served by choosing from first and second groups one for each and in addition to these one or two from third group. [1-2-3]
- *Variety of the Menu:* To be able to provide the menu diversity during planned time; each food should be chosen from first and third groups meals maximum 1 time and minimum 1, maximum 3 times from second group. [4-5-6] Each food served any day should be given again 5 days later at the earliest.[7]
- *Energy and Nutrient Values:* Due to the fact that the term of a portion is relative, the amount of nutrients and energy in a portion will be different. Therefore, the energy and nutritional values of a portion is fuzzied with 5 percentage from left and right. The applicability of increasement in the energy and values of nutrient of food decreases as the values of energy and nutrient increase. In other words, as a meal's energy and nutrient value increase, so as the degree of membership decreases. For this reason, the fuzzied number is assumed to have a membership function that linearly decreasing.
- *Energy and Nutrient Element Needs:* The values in the table 1 are average values and calculated without bread. But, energy and nutrient element needs change for each staff in real life according to gender, age, physical characteristics, occupation and so on. Moreover, because of the fact that the amount of bread that is eaten by each worker is different, the nutrient element and energy amount that are taken from eaten bread will also be different. That is why the value of energy and nutrient element needs are fuzzied with 5 percentages from right and left and then used in the model as functional membership that linearly increases. [8-9-10-11]

Here are some rules to be taken into consideration while creating skeleton of meal groups. These rules can be listed as follows (Ediz and Yağdıran, 2009):

- Meaty vegetable meats should not be served next to the olive oil vegetable meals. [12]
- Dolmas (a Turkish food) should not be served next to rice. [13]
- Rice based meals should be preferred next to meaty legume meals. [14]
- With rice, pasta and pastries, dessert should be served. [15]
- Salad should not be served next to olive oil vegetable dishes. [16]
- Salad should not be served next to meaty vegetable dishes. [17]
- Mutter milk should not be served next to soups. [18]
- Dishes include potatoes should not be served together. [19]
- Dishes include yoghurt should not be served together. [20]
- Dishes include rise should not be served at the same time. [21]
- Dishes include carrots should not be served together. [22]
- Dishes include beans and squash should not be served together. [23]

Establishment of the Model

Decision Variables:

$$FG_{ij} = \begin{cases} 1 & \text{if i. food is served on j. day} \\ 0 & \text{if i. food is not served on j. day} \end{cases} \qquad i = 1, 2, \ldots, 22 \qquad j = 1, 2, \ldots, 20$$

$$SG_{ij} = \begin{cases} 1 & \text{if i. food is served on j. day} \\ 0 & \text{if i. food is not served on j. day} \end{cases} \qquad i = 1, 2, \ldots, 18 \qquad j = 1, 2, \ldots, 20$$

$$TG_{ij} = \begin{cases} 1 & \text{if i. food is served on j. day} \\ 0 & \text{if i. food is not served on j. day} \end{cases} \qquad i = 1, 2, \ldots, 24 \qquad j = 1, 2, \ldots, 20$$

Objective Function:

$$Z_{min} = \sum_{j=1}^{20} \sum_{i=1}^{22} \tilde{C}_i * FG_{ij} + \sum_{j=1}^{20} \sum_{i=1}^{18} \tilde{C}_i * SG_{ij} \sum_{j=1}^{20} \sum_{i=1}^{24} \tilde{C}_i * TG_{ij}$$

Constrains:

$$\sum_{i=1}^{22} FG_{ij} = 1 \qquad j = 1, 2, \ldots, 20 \quad \ldots\ldots\ldots\ldots [1]$$

$$1 \le \sum_{i=1}^{18} SG_{ij} \le 2 \qquad j = 1, 2, \ldots, 20 \quad \ldots\ldots\ldots\ldots [2]$$

$$\sum_{i=1}^{24} TG_{ij} = 1 \qquad j = 1, 2, \ldots, 20 \quad \ldots\ldots\ldots\ldots [3]$$

$$\sum_{j=1}^{20} FG_{ij} \le 1 \qquad i = 1, 2, \ldots, 22 \quad \ldots\ldots\ldots\ldots [4]$$

$$1 \le \sum_{j=1}^{20} SG_{ij} \le 3 \qquad i = 1, 2, \ldots, 20 \quad \ldots\ldots\ldots\ldots [5]$$

$$\sum_{j=1}^{20} TG_{ij} \le 1 \qquad i = 1, 2, \ldots, 22 \quad \ldots\ldots\ldots\ldots [6]$$

$$\sum_{j=n}^{n+4} TG_{ij} = 1 \qquad n = 1, 2, \ldots, 16 \qquad i = 1, 2, \ldots, 22 \quad \ldots\ldots\ldots\ldots [7]$$

$$\sum_{i=1}^{22} \tilde{E}_i * FG_{ij} + \sum_{i=1}^{18} \tilde{E}_i * SG_{ij} + \sum_{i=1}^{24} \tilde{E}_i * TG_{ij} \ge \tilde{750} \qquad j = 1, 2, \ldots, 20 \quad \ldots\ldots\ldots\ldots [8]$$

$$\sum_{i=1}^{22} \tilde{P}_i * FG_{ij} + \sum_{i=1}^{18} \tilde{P}_i * SG_{ij} + \sum_{i=1}^{24} \tilde{P}_i * TG_{ij} \ge \tilde{22,7} \qquad j = 1, 2, \ldots, 20 \quad \ldots\ldots\ldots\ldots [9]$$

$$\sum_{i=1}^{22}\tilde{T}_i * FG_{ij} + \sum_{i=1}^{18}\tilde{T}_i * SG_{ij} + \sum_{i=1}^{24}\tilde{T}_i * TG_{ij} \geq \tilde{0,38} \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[10]$$

$$\sum_{i=1}^{22}\tilde{CV}_i * FG_{ij} + \sum_{i=1}^{18}\tilde{CV}_i * SG_{ij} + \sum_{i=1}^{24}\tilde{CV}_i * TG_{ij} \geq \tilde{34} \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[11]$$

$$\sum_{i=13}^{22} FG_{ij} + \sum_{i=1}^{6} SG_{ij} \leq 1 \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[12]$$

$$\sum_{i=19}^{20} FG_{ij} + \sum_{i=12}^{13} SG_{ij} \leq 1 \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[13]$$

$$\sum_{i=21}^{22} FG_{ij} + \sum_{i=1}^{6} SG_{ij} + \sum_{i=14}^{18} SG_{ij} \leq 1 \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[14]$$

$$\sum_{i=12}^{18} SG_{ij} + \sum_{i=1}^{4} TG_{ij} \leq 1 \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[15]$$

$$\sum_{i=1}^{6} SG_{ij} + \sum_{i=5}^{8} TG_{ij} \leq 1 \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[16]$$

$$\sum_{i=13}^{22} FG_{ij} + \sum_{i=5}^{8} TG_{ij} \leq 1 \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[17]$$

$$\sum_{i=7}^{11} SG_{ij} + TG_{22j} \leq 1 \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[18]$$

$$\sum_{i=1}^{6} FG_{ij} + FG_{10j} + FG_{12j} + FG_{16j} + SG_{6j} + TG_{8j} \leq 1 \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[19]$$

$$FG_{15j} + FG_{20j} + SG_{5j} + SG_{8j} + TG_{22j} + TG_{23j} \leq 1 \qquad j=1,2,....20 \ldots\ldots\ldots\ldots[20]$$

$$FG_{4j} + FG_{7j} + FG_{11j} + \sum_{i=19}^{20} FG_{ij} + \sum_{i=2}^{3} SG_{ij} + SG_{8j} + SG_{12j} + TG_{1j} \leq 1 \qquad j=1,2,..20 \ldots\ldots[21]$$

$$FG_{3j} + \sum_{i=7}^{9} FG_{ij} + SG_{6j} \leq 1 \qquad j=1,2,..20 \ldots\ldots\ldots\ldots[22]$$

$$\sum_{i=8}^{9} FG_{ij} + \sum_{i=16}^{17} FG_{ij} + \sum_{i=20}^{21} FG_{ij} + SG_{4j} \leq 1 \qquad j=1,2,..20 \ldots\ldots\ldots\ldots[23]$$

The membership function of energy need fuzzy data can be calculated as follows:

$$E = 787,5\mu_{\tilde{E}} + 712,5(1-\mu_{\tilde{E}}) = 712,5 + 75\mu_{\tilde{E}}$$

The constrains, of which right side constants are fuzzy, are written below as in the form of membership function. All other fuzzy data and membership functions are given in the table 3.

$$\sum_{i=1}^{22}\tilde{E}_i * FG_{ij} + \sum_{i=1}^{18}\tilde{E}_i * SG_{ij} + \sum_{i=1}^{24}\tilde{E}_i * TG_{ij} \geq 712{,}5 + 75\mu_{\tilde{E}} \qquad j = 1, 2, \ldots 20 \ldots\ldots\ldots\ldots [8]$$

$$\sum_{i=1}^{22}\tilde{P}_i * FG_{ij} + \sum_{i=1}^{18}\tilde{P}_i * SG_{ij} + \sum_{i=1}^{24}\tilde{P}_i * TG_{ij} \geq 21{,}57 + 2{,}27\mu_{\tilde{P}} \qquad j = 1, 2, \ldots 20 \ldots\ldots\ldots\ldots [9]$$

$$\sum_{i=1}^{22}\tilde{T}_i * FG_{ij} + \sum_{i=1}^{18}\tilde{T}_i * SG_{ij} + \sum_{i=1}^{24}\tilde{T}_i * TG_{ij} \geq 0{,}36 + 0{,}04\mu_{\tilde{T}} \qquad j = 1, 2, \ldots 20 \ldots\ldots\ldots\ldots [10]$$

$$\sum_{i=1}^{22}\tilde{CV}_i * FG_{ij} + \sum_{i=1}^{18}\tilde{CV}_i * SG_{ij} + \sum_{i=1}^{24}\tilde{CV}_i * TG_{ij} \geq 32{,}3 + 3{,}4\mu_{\tilde{CV}} \qquad j = 1, 2, \ldots 20 \ldots\ldots\ldots\ldots [11]$$

4.CONCLUSIONS

According to suggested model; menus that are obtained for the 3 different membership functions (0, 0,5 ve 1) are given at the table 4. Menus that are not possible to apply are shown in the column of μ=0 and certain applicable menus are shown at the μ=1. 20 days' menu costs of each person for these membership degrees are found respectively as 27,34 TL, 28,34 TL and 32,38 TL. In other words, the costs of menus for each person can vary between 27,34 TL - 32,38 TL

As it is clearly seen in this study, menu planning is such a complicated process that many different elements should be taken into consideration during the period. It is quite hard in a handmade menu planning to take all necessary conditions into consideration to obtain minimum costs. Because of this reason, making a menu planning via mathematical models not only helps to save time but also helps to eliminate possible mistakes. Additionally regarding the fuzziness of the data gains a flexibility for models.

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Note 1: Numbers that are in the square brackets indicate constraint numbers in model.

Table 2. The Information of the Meals

		Meal Kods	The Name of Meals	Total Energy and Nutrient Values of a Portion Meals				The Cost of The Meals (TL)
				Energy (kcal)	Protein (gr)	Thiamin (mg)	Vitamin C (mg)	
				E_i	P_i	T_i	N_i	
The First Group Meals	Meat Dishes	FG_1	Cold Cuts	339	19,6	0,1	12,4	1,227
		FG_2	Roast Meat	348	18,4	0,1	12,3	1,191
		FG_3	Boiled Veal	369,4	36,6	0,1	8,8	1,209
		FG_4	Kadınbudu Meatballs	417	16,2	0,2	15,2	0,985
		FG_5	Oven Meatballs	309	15,4	0,2	15,2	0,905
		FG_6	İzmir Meatballs	343	14,6	0,2	14,1	0,877
		FG_7	Rosted Lamb	416,6	43	0,2	0,3	1,708
		FG_8	Schnitzel Chicken	534,2	54,7	0,3	18,1	1,047
		FG_9	Grilled Chicken	337,6	47,8	0,2	18,4	0,978
		FG_{10}	Boiled Chicken	259	26,2	0,2	14,6	0,646
		FG_{11}	Chicken with soy sauce	315,1	39,9	0,1	0,1	0,795
		FG_{12}	Whitefish	489,6	52,3	0,3	33	0,916
	Vegetable Dishes With Meat	FG_{13}	Cabbage stew	190	10,3	0,1	65,8	0,662
		FG_{14}	Cauliflower	187	11,3	0,2	121,3	0,799
		FG_{15}	Spinach and rice with minced meat	276	15,6	0,2	77,8	0,853
		FG_{16}	Mixed vegetable pot	221	10,1	0,1	31,7	0,700
		FG_{17}	Green beans with meat	222	11,1	0,2	41,3	0,774
		FG_{18}	Stuffed Eggplant	270	9,6	0,1	22,8	0,845
		FG_{19}	Rice and minced meat stuffed bell peppers	226	11,2	0,1	84,2	0,908
		FG_{20}	Stuffed courgettes	247	11,1	0,1	21,7	0,862
		FG_{21}	Dry bean with meat	336	19,1	0,3	3,3	0,518

			FG_{22}	**Chick peas with meat**	350	17,4	0,3	2,3	0,516
The Second Group Meals		**With Olive Oil**	SG_1	**Imambayıldı**	194	2,1	0,1	18,3	0,293
			SG_2	**Stuffed green peppers with olive oil**	265	4,6	0,1	88,8	0,444
			SG_3	**Stuffed grape leaves with olive oil**	268	4,7	0,1	42,1	0,327
			SG_4	**Green runner beans**	177	3,5	0,1	38	0,267
			SG_5	**Horse bean with olive oil**	266	11,3	0,5	46,5	0,362
			SG_6	**Kidney bean with olive oil**	328	13,3	0,2	10	0,274

Table 2. The Information of the Meals (Cont.)

		Meal Kods	**The Name of Meals**	**Total Energy and Nutrient Values of a Portion Meals**				**The Cost of The Meals (TL)**
				Energy (kcal)	**Protein (gr)**	**Thiamin (mg)**	**Vitamin C (mg)**	
				E_i	P_i	T_i	N_i	
	Soaps	SG_7	**Tomato**	161	3,4	0,1	1,3	0,094
		SG_8	**Yoghurt**	115	3,3	0,1	0,3	0,092
		SG_9	**Lentil**	183	7,9	0,2	2,2	0,063
		SG_{10}	**Noodle**	115	1,8	0	0,3	0,066
		SG_{11}	**Flour**	184	2,8	0,1	0	0,043
	Pilafs and Pastas	SG_{12}	**Rice Pilaf**	336	4,7	0,1	0	0,129
		SG_{13}	**Bulgur Pilaf**	291	6,5	0,2	10,5	0,068
		SG_{14}	**Macaroni timbale**	505	19,4	0,2	0,4	0,433
		SG_{15}	**Macaroni with cheese**	354	10,7	0,1	0	0,208
	Pies	SG_{16}	**Rolled pastry**	421	15	0,3	3,3	0,610
		SG_{17}	**Water heurek**	293,1	9,4	0,1	6,7	0,237
		SG_{18}	**Spinach Pie**	368,5	11,1	0,1	22,4	0,326
Group Desserts		TG_1	**Rice Pudding**	347	8,4	0,1	2,2	0,372

		TG_2	**Syrup-soaked pastry**	512,3	4,3	0	0,2	0,218
		TG_3	**Sekerpare**	482,6	5	0	0,2	0,215
		TG_4	**Revani**	367,6	4,8	0	0,2	0,208
	Salads	TG_5	**Mixed Salad**	123	1,3	0,1	28,8	0,278
		TG_6	**Curly Salad**	84	0,9	0,1	10,6	0,241
		TG_7	**Shepherd Salad**	113	1,8	0,1	52,2	0,301
		TG_8	**Potato Salad**	184,9	3,8	0,2	63,5	0,261
	Fruits	TG_9	**Apple**	101	0,5	0	10	0,281
		TG_{10}	**Apricot**	72	0,9	0	11	0,270
		TG_{11}	**Banana**	153,3	1,8	0	13,8	0,529
		TG_{12}	**Cherry**	63	1,6	0	14	0,413
		TG_{13}	**Grape**	108	0,9	0,1	4	0,300
		TG_{14}	**Melon**	77	1,4	0,1	80	0,233
		TG_{15}	**Watermelon**	73	1,3	0,1	15	0,175
		TG_{16}	**Orange**	69	1,1	0,1	83	0,186
		TG_{17}	**Mandarin**	70	1	0,1	46	0,238
		TG_{18}	**Pearch**	83	1,1	0	39	0,247
		TG_{19}	**Pears**	113	0,5	0	10	0,248
		TG_{20}	**Strawberry**	57	1,1	0	100	0,180
		TG_{21}	**Plum**	59	0,7	0	9	0,188
	Others	TG_{22}	**Buttermilk**	45	2,6	0	0	0,250
		TG_{23}	**Yogurt**	194	10,56	0,2	3	0,330
		TG_{24}	**Pickle**	10	0,6	0	0,7	0,480

Source: Şenol 2011, 74-125.

Table 3. Fuzzy Data and Membership Functions

M. Kods	Energy (kcal)			Protein (gr)			Thiamin (mg)			Vitamin C (mg)			The Cost of The Meals		
	E^L	E^U	M.Ship Funct.	P^L	P^U	M.Ship Funct.	T^L	T^U	M.Ship Funct.	CV^L	CV^U	M.Ship Funct.	C^L	C^U	M.Ship Funct.
FG_1	322,05	355,95	355,95-33,9μ	18,62	20,58	20,58-1,96μ	0,10	0,11	0,11-0,01μ	11,78	13,02	13,02-1,24μ	1,17	1,29	1,17+0,12μ
FG_2	330,60	365,40	365,4-34,8μ	17,48	19,32	19,32-1,84μ	0,10	0,11	0,11-0,01μ	11,69	12,92	12,915-1,23μ	1,13	1,25	1,13+0,12μ
FG_3	350,93	387,87	387,87-36,94μ	34,77	38,43	38,43-3,66μ	0,10	0,11	0,11-0,01μ	8,36	9,24	9,24-0,88μ	1,15	1,27	1,15+0,12μ
FG_4	396,15	437,85	437,85-41,7μ	15,39	17,01	17,01-1,62μ	0,19	0,21	0,21-0,02μ	14,44	15,96	15,96-1,52μ	0,94	1,03	0,94+0,1μ
FG_5	293,55	324,45	324,45-30,9μ	14,63	16,17	16,17-1,54μ	0,19	0,21	0,21-0,02μ	14,44	15,96	15,96-1,52μ	0,86	0,95	0,86+0,09μ
FG_6	325,85	360,15	360,15-34,3μ	13,87	15,33	15,33-1,46μ	0,19	0,21	0,21-0,02μ	13,40	14,81	14,81-1,41μ	0,83	0,92	0,83+0,09μ
FG_7	395,77	437,43	437,43-41,66μ	40,85	45,15	45,15-4,3μ	0,19	0,21	0,21-0,02μ	0,29	0,32	0,312-0,03μ	1,62	1,79	1,62+0,17μ
FG_8	507,49	560,91	560,91-53,42μ	51,97	57,44	57,44-5,47μ	0,29	0,32	0,32-0,03μ	17,20	19,01	19,06-1,81μ	0,99	1,1	0,99+0,1μ
FG_9	320,72	354,48	354,48-33,76μ	45,41	50,19	50,19-4,78μ	0,19	0,21	0,21-0,02μ	17,48	19,32	19,32-1,84μ	0,93	1,03	0,93+0,1μ
FG_{10}	246,05	271,95	271,95-25,9μ	24,89	27,51	27,51-2,62μ	0,19	0,21	0,21-0,02μ	13,87	15,33	15,33-1,46μ	0,61	0,68	0,61+0,06μ
FG_{11}	299,35	330,86	330,86-31,51μ	37,91	41,90	41,9-3,99μ	0,10	0,11	0,105-0,01μ	0,10	0,11	0,11-0,01μ	0,76	0,83	0,76+0,08μ
FG_{12}	465,12	514,08	514,08-48,96μ	49,69	54,92	54,92-5,23μ	0,29	0,32	0,32-0,03μ	31,35	34,65	34,65-3,3μ	0,87	0,96	0,87+0,09μ
FG_{13}	180,50	199,50	199,5-19μ	9,79	10,82	10,82-1,03μ	0,10	0,11	0,11-0,01μ	62,51	69,09	69,09-6,58μ	0,63	0,7	0,63+0,07μ
FG_{14}	177,65	196,35	196,35-18,7μ	10,74	11,87	11,87-1,13μ	0,19	0,21	0,21-0,02μ	115,24	127,37	127,37-12,13μ	0,76	0,84	0,76+0,08μ
FG_{15}	262,20	289,80	289,8-27,6μ	14,82	16,38	16,38-1,56μ	0,19	0,21	0,21-0,02μ	73,91	81,69	81,69-7,78μ	0,81	0,9	0,81+0,09μ

FG_{16}	209,95	232,05	232,05-22,1μ	9,60	10,61	10,61-1,01μ	0,10	0,11	0,11-0,01μ	30,12	33,29	33,29-3,17μ	0,67	0,74	0,67+0,07μ
FG_{17}	210,90	233,10	233,1-22,2μ	10,55	11,66	11,66-1,11μ	0,19	0,21	0,21-0,02μ	39,24	43,37	43,37-4,13μ	0,74	0,81	0,74+0,08μ
FG_{18}	256,50	283,50	283,5-27μ	9,12	10,08	10,08-0,96μ	0,10	0,11	0,11-0,01μ	21,66	23,94	23,94-2,28μ	0,8	0,89	0,8+0,08μ
FG_{19}	214,70	237,30	237,3-22,6μ	10,64	11,76	11,76-1,12μ	0,10	0,11	0,11-0,01μ	79,99	88,41	88,41-8,42μ	0,86	0,95	0,86+0,09μ
FG_{20}	234,65	259,35	259,35-24,7μ	10,55	11,66	11,655-1,11μ	0,10	0,11	0,11-0,01μ	20,62	22,79	22,79-2,17μ	0,82	0,91	0,82+0,09μ
FG_{21}	319,20	352,80	352,8-33,6μ	18,15	20,06	20,06-1,91μ	0,29	0,32	0,32-0,03μ	3,14	3,47	3,47-0,33μ	0,49	0,54	0,49+0,05μ
FG_{22}	332,50	367,50	367,5-35μ	16,53	18,27	18,27-1,74μ	0,29	0,32	0,32-0,03μ	2,19	2,42	2,42-0,23μ	0,49	0,54	0,49+0,05μ
SG_{1}	184,30	203,70	203,7-19,4μ	2,00	2,21	2,205-0,21μ	0,10	0,11	0,11-0,01μ	17,39	19,22	19,22-1,83μ	0,28	0,31	0,28+0,03μ
SG_{2}	251,75	278,25	278,25-26,5μ	4,37	4,83	4,83-0,46μ	0,10	0,11	0,11-0,01μ	84,36	93,24	93,24-8,88μ	0,42	0,47	0,42+0,04μ
SG_{3}	254,60	281,40	281,4-26,8μ	4,47	4,94	4,94-0,47μ	0,10	0,11	0,11-0,01μ	40,00	44,21	44,21-4,21μ	0,31	0,34	0,31+0,03μ
SG_{4}	168,15	185,85	185,85-17,7μ	3,33	3,68	3,68-0,35μ	0,10	0,11	0,11-0,01μ	36,10	39,90	39,9-3,8μ	0,25	0,28	0,25+0,03μ
SG_{5}	252,70	279,30	279,3-26,6μ	10,74	11,87	11,87-1,13μ	0,48	0,53	0,53-0,05μ	44,18	48,83	48,83-4,65μ	0,34	0,38	0,34+0,04μ
SG_{6}	311,60	344,40	344,4-32,8μ	12,64	13,97	13,97-1,33μ	0,19	0,21	0,21-0,02μ	9,50	10,50	10,5-1μ	0,26	0,29	0,26+0,03μ
SG_{7}	152,95	169,05	169,05-16,1μ	3,23	3,57	3,57-0,34μ	0,10	0,11	0,11-0,01μ	1,24	1,37	1,37-0,13μ	0,09	0,1	0,09+0,01μ
SG_{8}	109,25	120,75	120,75-11,5μ	3,14	3,47	3,47-0,33μ	0,10	0,11	0,11-0,01μ	0,29	0,32	0,32-0,03μ	0,09	0,1	0,09+0,01μ
SG_{9}	173,85	192,15	192,15-18,3μ	7,51	8,30	8,3-0,79μ	0,19	0,21	0,21-0,02μ	2,09	2,31	2,31-0,22μ	0,06	0,07	0,06+0,01μ
SG_{10}	109,25	120,75	120,75-11,5μ	1,71	1,89	1,89-0,18μ	0	0	0	0,29	0,32	0,32-0,03μ	0,06	0,07	0,06+0,01μ

Table 3. Fuzzy Data and Membership Functions (Cont.)

M. Kods	Energy (kcal)			Protein (gr)			Thiamin (mg)			Vitamin C (mg)			The Cost of The Meals		
	E^L	E^U	M.Ship Funct.	P^L	P^U	M.Ship Funct.	T^L	T^U	M.Ship Funct.	CV^L	CV^U	M.Ship Funct.	C^L	C^U	M.Ship Funct.
SG_{11}	174,80	193,20	193,2-18,4μ	2,66	2,94	2,94-0,28μ	0,10	0,11	0,11-0,01μ	0	0	0	0,04	0,05	0,04+0μ
SG_{12}	319,20	352,80	352,8-33,6μ	4,47	4,94	4,94-0,47μ	0,10	0,11	0,11-0,01μ	0	0	0	0,12	0,14	0,12+0,01μ
SG_{13}	276,45	305,55	305,55-29,1μ	6,18	6,83	6,83-0,65μ	0,19	0,21	0,21-0,02μ	9,98	11,03	11,03-1,05μ	0,06	0,07	0,06+0,01μ
SG_{14}	479,75	530,25	530,25-50,5μ	18,43	20,37	20,37-1,94μ	0,19	0,21	0,21-0,02μ	0,38	0,42	0,42-0,04μ	0,41	0,45	0,41+0,04μ
SG_{15}	336,30	371,70	371,7-35,4μ	10,17	11,24	11,24-1,07μ	0,10	0,11	0,11-0,01μ	0	0	0	0,2	0,22	0,2+0,02μ
SG_{16}	399,95	442,05	442,05-42,1μ	14,25	15,75	15,75-1,5μ	0,29	0,32	0,32-0,03μ	3,14	3,47	3,47-0,33μ	0,58	0,64	0,58+0,06μ
SG_{17}	278,45	307,76	307,76-29,31μ	8,93	9,87	9,87-0,94μ	0,10	0,11	0,11-0,01μ	6,37	7,04	7,04-0,67μ	0,23	0,25	0,23+0,02μ
SG_{18}	350,08	386,93	386,93-36,85μ	10,55	11,66	11,66-1,11μ	0,10	0,11	0,11-0,01μ	21,28	23,52	23,52-2,24μ	0,31	0,34	0,31+0,03μ
TG_1	329,65	364,35	364,35-34,7μ	7,98	8,82	8,82-0,84μ	0,10	0,11	0,11-0,01μ	2,09	2,31	2,31-0,22μ	0,35	0,39	0,35+0,04μ
TG_2	486,69	537,92	537,92-51,23μ	4,09	4,52	4,52-0,43μ	0	0	0	0,19	0,21	0,21-0,02μ	0,21	0,23	0,21+0,02μ
TG_3	458,47	506,73	506,73-48,26μ	4,75	5,25	5,25-0,5μ	0	0	0	0,19	0,21	0,21-0,02μ	0,2	0,23	0,2+0,02μ
TG_4	349,22	385,98	385,98-36,76μ	4,56	5,04	5,04-0,48μ	0	0	0	0,19	0,21	0,21-0,02μ	0,2	0,22	0,2+0,02μ
TG_5	116,85	129,15	129,15-12,3μ	1,24	1,37	1,365-0,13μ	0,10	0,11	0,11-0,01μ	27,36	30,24	30,24-2,88μ	0,26	0,29	0,26+0,03μ
TG_6	79,80	88,20	88,2-8,4μ	0,86	0,95	0,95-0,09μ	0,10	0,11	0,11-0,01μ	10,07	11,13	11,13-1,06μ	0,23	0,25	0,23+0,02μ
TG_7	107,35	118,65	118,65-11,3μ	1,71	1,89	1,89-0,18μ	0,10	0,11	0,11-0,01μ	49,59	54,81	54,81-5,22μ	0,29	0,32	0,29+0,03μ

TG_8	175,66	194,15	194,15-18,49µ	3,61	3,99	3,99-0,38µ	0,19	0,21	0,21-0,02µ	60,33	66,68	66,68-6,35µ	0,25	0,27	0,25+0,03µ
TG_9	95,95	106,05	106,05-10,1µ	0,48	0,53	0,53-0,05µ	0	0	0	9,5	10,5	10,5-1µ	0,27	0,3	0,27+0,03µ
TG_{10}	68,40	75,60	75,6-7,2µ	0,86	0,95	0,95-0,09µ	0	0	0	10,45	11,55	11,55-1,1µ	0,26	0,28	0,26+0,03µ
TG_{11}	145,64	160,97	160,97-15,33µ	1,71	1,89	1,89-0,18µ	0	0	0	13,11	14,49	14,49-1,38µ	0,5	0,56	0,5+0,05µ
TG_{12}	59,85	66,15	66,15-6,3µ	1,52	1,68	1,68-0,16µ	0	0	0	13,3	14,7	14,7-1,4µ	0,39	0,43	0,39+0,04µ
TG_{13}	102,60	113,40	113,4-10,8µ	0,86	0,95	0,95-0,09µ	0,10	0,11	0,11-0,01µ	3,8	4,2	4,2-0,4µ	0,29	0,32	0,29+0,03µ
TG_{14}	73,15	80,85	80,85-7,7µ	1,33	1,47	1,47-0,14µ	0,095	0,105	0,105-0,01µ	76	84	84-8µ	0,22	0,24	0,22+0,02µ
TG_{15}	69,35	76,65	76,65-7,3µ	1,24	1,37	1,37-0,13µ	0,095	0,105	0,105-0,01µ	14,25	15,75	15,75-1,5µ	0,17	0,18	0,17+0,02µ
TG_{16}	65,55	72,45	72,45-6,9µ	1,05	1,16	1,16-0,11µ	0,095	0,105	0,105-0,01µ	78,85	87,15	87,15-8,3µ	0,18	0,2	0,18+0,02µ
TG_{17}	66,50	73,50	73,5-7µ	0,95	1,05	1,05-0,1µ	0,095	0,105	0,105-0,01µ	43,7	48,3	48,3-4,6µ	0,23	0,25	0,23+0,02µ
TG_{18}	78,85	87,15	87,15-8,3µ	1,05	1,16	1,16-0,11µ	0	0	0-0µ	37,05	40,95	40,95-3,9µ	0,23	0,26	0,23+0,02µ
TG_{19}	107,35	118,65	118,65-11,3µ	0,48	0,53	0,53-0,05µ	0	0	0-0µ	9,5	10,5	10,5-1µ	0,24	0,26	0,24+0,02µ
TG_{20}	54,15	59,85	59,85-5,7µ	1,05	1,16	1,16-0,11µ	0	0	0-0µ	95	105	105-10µ	0,17	0,19	0,17+0,02µ
TG_{21}	56,05	61,95	61,95-5,9µ	0,67	0,74	0,74-0,07µ	0	0	0-0µ	8,55	9,45	9,45-0,9µ	0,18	0,2	0,18+0,02µ
TG_{22}	42,75	47,25	47,25-4,5µ	2,47	2,73	2,73-0,26µ	0	0	0-0µ	0	0	0	0,24	0,26	0,24+0,03µ
TG_{23}	184,30	203,70	203,7-19,4µ	10,03	11,09	11,09-1,06µ	0,19	0,21	0,21-0,02µ	2,85	3,15	3,15-0,3µ	0,31	0,35	0,31+0,03µ
TG_{24}	9,50	10,50	10,5-1µ	0,57	0,63	0,63-0,06µ	0	0	0-0µ	0,67	0,74	0,74-0,07µ	0,46	0,5	0,46+0,05µ

Table 4. Menus According to Membership Degrees

Day	μ=0	μ=0.5	μ=1
1	Yoghurt Soap	Lentil Soap	Roast Meat
	Cauliflower	Mixed vegetable pot	Horse bean with olive oil
	Macaroni with cheese	Bulgur Pilaf	Sekerpare
	Apricot	Plum	
2	Lentil Soap	Flour Soap	Yoghurt Soap
	Rosted Lamb	Stuffed courgettes	Stuffed Eggplant
	Shepherd Salad	Macaroni with cheese	Rolled pastry
		Melon	Cherry
3	Flour Soap	Noodle Soap	Rosted Lamb
	Boiled Chicken	Cabbage stew	Bulgur Pilaf
	Stuffed grape leaves with olive oil	Rolled pastry	Potato Salad
	Grape	Apricot	
4	Roast Meat	Schnitzel Chicken	Lentil Soap
	Horse bean with olive oil	Stuffed green peppers with olive oil	Dry bean with meat
	Revani	Grape	Rice Pilaf
			Strawberry
5	Soya Soslu Tavuk (Rice Pilaf G.)	Yoghurt Soap	Soya Soslu Tavuk (Rice Pilaf G.)
	Kidney bean with olive oil	Stuffed Eggplant	Kidney bean with olive oil
	Melon	Spinach Pie	Tomato Soap
		Mandarin	Orange
6	Yoghurt Soap	Grilled Chicken	Kadınbudu Meatballs
	Mixed vegetable pot	Rice Pilaf	Stuffed grape leaves with olive oil

	Macaroni timbale	Potato Salad	Flour Soap
	Apple		Melon
7	Lentil Soap	Flour Soap	İzmir Meatballs
	Cabbage stew	Cauliflower	Green runner beans
	Rice Pilaf	Water heurek	Noodle Soap
	Plum	Pears	Yogurt
8	Flour Soap	Lentil Soap	Yoghurt Soap
	Green runner beans	İmambayıldı	Boiled Veal
	Oven Meatballs	Roast Meat	Bulgur Pilaf
	Sekerpare	Watermelon	Mixed Salad
9	Dry bean with meat	Noodle Soap	Lentil Soap
	Bulgur Pilaf	Stuffed grape leaves with olive oil	Cabbage stew
	Sekerpare	Boiled Chicken	Rolled pastry
		Yoğurt	Plum
10	Whitefish	Kadınbudu Meatballs	Tomato Soap
	Spinach Pie	Maccaroni with cheese	Spinach and rice with minced meat
	Buttermilk	Mixed Salad	Spinach Pie
			Watermelon

Table 4. Menus According to Membership Degrees (Cont.)

11	İzmir Meatballs	Boiled Veal	Flour Soap
	Water heurek	Horse bean with olive oil	İmambayıldı
	Curly Salad	Revani	Grilled Chicken
			Rice Pudding
12	Noodle Soap	Soya Soslu Tavuk (Rice Pilaf G.)	Noodle Soap
	Schnitzel Chicken	Kidney bean with olive oil	Cauliflower

	Potato Salad	Bulgur Pilaf	Macaroni timbale
		Orange	Grape
13	Stuffed courgettes	Lentil Soap	Schnitzel Chicken
	Rolled pastry	Spinach and rice with minced meat	Stuffed green peppers with olive oil
	Mandarin	Sekerpare	Mandarin
14	Kadınbudu Meatballs	Flour Soap	Cold cuts
	Bulgur Pilaf	Cold cuts	Horse bean with olive oil
	Mixed Salad	Spinach Pie	Revani
		Curly Salad	
15	Lentil Soap	Whitefish	Tomato Soap
	Green beans with meat	Rice Pilaf	Chick peas with meat
	Syrup-soaked pastry	Apple	Rice Pilaf
			Pearch
16	Spinach and rice with minced meat	Tomato Soap	Lentil Soap
	Macaroni timbale	Stuffed grape leaves with olive oil	Oven Meatballs
	Pearch	İzmir Meatballs	Water heurek
		Syrup-soaked pastry	Shepherd Salad
17	Cold cuts	Green beans with meat	Flour Soap
	İmambayıldı	Macaroni timbale	Mixed vegetable pot
	Yoğurt	Buttermilk	Rolled pastry
			Apple
18	Flour Soap	Noodle Soap	Boiled Chicken
	Stuffed green peppers with olive oil	Dry bean with meat	Green runner beans

	Boiled Veal	Bulgur Pilaf	Bulgur Pilaf
	Orange	Strawberry	Pears
19	Grilled Chicken	Oven Meatballs	Yoghurt Soap
	Bulgur Pilaf	Green runner beans	Green beans with meat
	Pears	Rice Pudding	Macaroni timbale
			Apricot
20	Tomato Soap	Chick peas with meat	Whitefish
	Stuffed Eggplant	Rice Pilaf	Maccaroni with cheese
	Maccaroni with cheese	Pearch	Curly Salad
	Watermelon		